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February 27, 2003

OSWER Docket
EPA West Building, Room B102
1301 Constitution Avenue, NW
Washington, DC 20004
Attention: Docket ID No. RCRA-2002-0033

Dear Madam / Sir:

The American Petroleum Institute (API) is the primary trade association for the oil and natural gas industry in the United States. Representing one of the most technologically advanced industries in the world, our membership includes more than 400 companies engaged in all aspects of the oil and gas industry, including the exploration, production, refining, transportation and marketing of crude petroleum and petroleum products. API is a major research institute that advances public policy positions based upon scientific, technical and economic research, and it develops standards and quality certification programs used throughout the world. API's public policy positions reflect a commitment to ensure a strong, viable U.S. oil and natural gas industry capable of meeting the energy needs of our Nation and providing consumers a reliable source of products in an efficient and environmentally responsible manner.

API appreciates the opportunity to comment on the Agency's "Draft Guidance For Evaluating the Vapor Intrusion to Indoor Air Pathway From Groundwater and Soils (Subsurface Vapor Intrusion Guidance)" [*Federal Register*, Volume 67, Number 230, Friday November 29, 2002]. API's members could be significantly impacted by the use and anticipated misapplication of the draft guidance in its current state. Comments and recommendations which address our concerns with the guidance are attached and presented. Our comments are presented in three sections. The first section summarizes major comments and recommendations, the second section contains detailed comments, and the final section contains a detailed analysis of EPA's "Vapor Intrusion Database" and further technical support for API's recommendations.

We hope you find our comments and recommendations constructive. We would be pleased to present our technical findings to the Agency in more detail at a mutually agreeable time.

Sincerely,

Harley Hopkins, PG
Regulatory Analysis and Scientific Affairs

American Petroleum Institute Comments on "Draft Guidance For Evaluating the Vapor Intrusion to Indoor Air Pathway From Groundwater and Soils (Subsurface Vapor Intrusion Guidance)" [*Federal Register*, Volume 67, Number 230, Friday November 29, 2002]

Section 1: Major Comments

Sites Where the Agency Suggests the Guidance Should be Used

API supports the Agency's reasoning and decision to recommend that the guidance document not be used at UST sites at this time. In addition, API strongly recommends that the Agency include an explicit statement warning users not to apply the guidance to any site with biodegradable petroleum hydrocarbon compounds including BTEX. Preferably, the Agency should address the BTEX compounds in its future UST or BTEX-only guidance. The scientific basis for differentiating these compounds from other volatile organic compounds (VOCs) addressed in the guidance is straightforward: Attenuation due to biodegradation of compounds such as BTEX, (which are universally recognized to readily biodegrade in the subsurface) is not considered in the conceptual model nor the calculated screening levels used in this guidance. Thus, using this guidance at a BTEX-only site will produce many false positives resulting misallocation of regulator and industry resources and unwarranted concerns from homeowners who will ultimately be affected by unnecessary in-home sampling events. Evidence is provided in Section 3 of our comments that the current EPA Vapor Intrusion Database does not support the application of this guidance to BTEX compounds and thus, they should be excluded from it.

API is committed to working closely with the Agency on the development of a BTEX-oriented guidance. There is sufficient information in the literature that when viewed collectively, convincingly demonstrates that at a vast majority of sites where petroleum hydrocarbons are present in groundwater at some distance below the building foundation, the risk to vapor intrusion is low. A BTEX-only guidance would be more appropriate for communicating the conditions that pose risks (e.g., high ambient background concentrations, and petroleum products in direct contact with buildings or utilities that enter buildings). A BTEX-only guidance could employ screening criteria developed from an analysis of an empirical database on BTEX sites and allow a range of options for assessing vapor attenuation, using multiple lines of evidence and techniques such as hydrocarbon and O_2 soil gas profiling.

Intent of the Guidance

The Agency states "The intent of this draft guidance is to provide a tool to help the user conduct a screening evaluation as to whether or not the vapor intrusion exposure pathway is complete and, if so, whether it poses an unacceptable risk to human health." We support the Agency's acknowledgement that "…[p]ersonnel who use this guidance document are free to modify the approach recommended in this guidance." This statement is particularly important because the screening levels in the guidance do not account for biodegradation of compounds such as BTEX. Therefore, anyone attempting to use this guidance to screen BTEX-only sites will by necessity need to employ alternative screening approaches. In order to clarify the real intent of the guidance, API recommends that the Agency state that the guidance and the screening levels are not intended for application at BTEX-only sites. This type of statement will help dissuade other regulatory programs (e.g., state voluntary cleanup and UST programs) from inappropriately adopting the current guidance that is oriented towards chlorinated compounds. Because the Agency has chosen to include biodegradable petroleum hydrocarbons such as the BTEX in Tables 2 and 3, API is convinced that the Agency will be placed in a difficult position defending an empirical screening approach for BTEX in any future UST-oriented or BTEX-only guidance while these overly-conservative screening values are "on the books."

Scope of the Guidance
API supports the Agency's scope of the guidance as stated in the section "Application of the Guidance to Non-Residential Scenarios", specifically its limitation to residential land use.

Delays to Various Programs
The February 5, 1999 *RCRA Corrective Action Current Human Exposures under Control EI* Guidance did not anticipate the development of this guidance. There is insufficient time for persons responsible for Eis to appropriately apply this guidance to all sites that are required to have EI determinations by 2005. Therefore, API recommends that the Agency explicitly state that use of the guidance is not required for 2005 Eis and that other scientifically-defensible approaches that were acceptable for currently completed EI determinations are also acceptable for EI yet to be completed.

Due to the guidance's conservative screening levels and prescriptive sampling and data quality requirements, we anticipate significant delays in the Brownfields program. Many scientifically sound, site-specific, assessments of the vapor pathway will be called into question and additional unnecessary sampling will result.

Site-Specific Evaluation is Too Prescriptive
The process for a site-specific evaluation is unnecessarily prescriptive in its data collection requirements. The Agency fails to recognize that site-specific evaluation procedures will vary from site to site and from program to program. Therefore, the adequacy of modeling input and other data needs to be considered site-specifically, not prescriptively. The guidance states that other technically sound approaches may be used in the site-specific evaluation. However, this statement cannot be reconciled with the prescriptive data collection requirements in the current guidance.

The guidance appears to safely screen out sites that do not require further action (due to the conservative screening levels in Tables 2 and 3). However, because vapor attenuation due to biodegradation was not considered in the Table 2 and 3 screening levels, the guidance will overestimate the number of BTEX-only sites needing site-specific evaluation. As a result, BTEX sites will have to be assessed under the prescriptive requirements of Question 6.

EPA's Vapor Intrusion Database Does Not Support Attenuation Factors Selected For Calculating Screening Values
Background indoor air sources have a clear and significant impact on the indoor air concentration data in the USEPA Vapor Intrusion Database. The analysis of this database presented in Appendix F does not adequately account for the impact of background indoor air sources on the measured attenuations factors. As a result, the upper-bound groundwater and subslab attenuation factors selected for development of groundwater and soil gas screening concentrations are not supported by the available data and dramatically over-predict vapor intrusion even at reasonable worst-case sites. As a result, most petroleum hydrocarbon sites will be forced to undergo prescriptive site-specific screening of Question 6 of the guidance. Additional details on our analysis of the USEPA Vapor Intrusion Database are provided in the following comments and in Section 3 to these comments.

Section 2. Additional Comments and Technical Backup

Guidance Section	Comment
II. Explanation of Vapor Intrusion, Section A	**Incremental Risk** The Agency should not approach this pathway from the perspective of the combined risk from contamination in the subsurface and from ambient air. The 1E-6 to 1E-4 risk is for Incremental Excess Lifetime Risk. This is clearly stated in RAGS. API recommends that the Agency should state that there are ambient concentrations and that when evaluated with a subsurface contribution there may be an unacceptable risk. The Agency should consider the resource implications of remediating a site because of the unknown amount of contribution from the subsurface.
II. Explanation of Vapor Intrusion, Section B How this Pathway is Different from Other Exposure Pathways	**Remedies for Vapor Intrusion Problems** The Agency should delete statements about exposure to vapors that suggest a lack of technical options for controlling exposure. If one can clean-up groundwater or soil to reduce ingestion risk, one can clean-up groundwater or soil to reduce/eliminate volatile emission risk.
IV. Use Of This Guidance, Section A. Under What Conditions Do We Recommend You Consider This Pathway / Guidance	**When to Consider the Possibility of Exposure** The guide lists three bullet points all links by "or". In other words, the guide recommends that the vapor intrusion pathway be evaluated if any of the three conditions is true: 1) volatile chemicals are located 100 ft or less in depth, 2) volatile chemicals are located in close proximity (100 ft laterally) to a current or future buildings, or 3) volatile chemicals are located within the footprint of a potential future building. In reality, the vapor intrusion pathway should be evaluated only if condition 1 and condition 2 or 3 are true. In other words, the vapor intrusion pathway should be evaluated only if volatile chemicals are 100 ft or less in depth **and** 100 ft or less laterally from a building. API recommends that the Agency change the "or" at the end of the first bullet to an "and". Volatile chemicals are defined for purposes of this program as those with a Henry's Law constant of $1x10^{-5}$ or greater. RAGS Part B is cited as support for this definition. In fact, RAGS Part B defines volatile chemicals as those having both a Henry's Law constant of $1x10^{-5}$ or greater ". . . and with a molecular weight of less than 200 g/mole." It is unclear why this guidance has eliminated the second of the criteria set out in the cited reference. This omission results in an inconsistency between the screening levels applied for the indoor air pathway and for other potential exposure pathways at RCRA and CERCLA sites. EPA Regions III and IX rely on both criteria in defining volatile chemicals for purposes of developing Risk-Based Concentrations (RBCs) and Preliminary Remediation Goals (PRGs), measures that are commonly used to define site assessment requirements and to carry out health risk screening at CERCLA and RCRA sites.

Section 2. Additional Comments and Technical Backup (Continued)

Guidance Section	Comment
IV. Use of this Guidance, Section B	**Setting Risk Management Goals** The Agency is unclear on the reasons why the guidance should not be used for setting risk management goals. How can the conclusions of this document be separated from risk management goals?
IV. Section H, How Should "Background" be Considered	**Control of Background Concentrations** The guidance recommends that "background" be reduced or controlled by conducting an inspection of the building prior to sampling and removing any identified potential indoor air sources. However, there are no data available to indicate whether the significant sources of background indoor air impacts can be effectively identified by a visual inspection. While these recommendations seem to make sense, API recommends that additional text should be added to this section to acknowledge that the effectiveness of these "background control" measures at reducing background indoor air impacts are site-specific and difficult to quantify *apriori*.
Sections IV, V & VI, Tiered Screening Process	**Tiered Screening Approach.** API supports the use of a tiered approach for the evaluation of this pathway. However, the document must more clearly acknowledge in each question that alternate technically defensible approaches may be used in the evaluation. **Usability of the Q&A Format** Sections IV, V and VI of the guidance provide detailed instructions for the screening steps outlined in Figure 2 of the guidance. Incorporation of the EI Determination-like Question/Answer framework into the main body of the guidance limits the flexibility in the evaluation approach. In the final guidance, the Q&A should be moved to the appendix. **Format of the Screening Questions** Each of the Questions (e.g., Q1, Q2, etc.) addressed in these sections includes explanatory text on 1) The goal of the question, and 2) Valuable pieces of information and/or cautions to keep in mind as the user attempts to answer the question. These pieces of information should be presented right after the question is initially stated in order to improve the chances that the user will actually read the information prior to answering the question. There is some valuable information and cautions provided in the explanatory text that the user may miss by simply going straight to answering the questions. After the explanatory text is provided, the original question could then be restated along with the Yes/No/insufficient information checkboxes for the user to complete. Spaces should be provided on the Q&A pages where users can provide details about alternative technical approaches.
Primary and Secondary Screening	**Data Adequacy** The questions regarding adequate characterization data should be asked at the beginning of the process, not multiple times during the Primary and Secondary Screening evaluation. It is particularly puzzling why the evaluator is asked whether the data are adequate only when it suggest screening out, not when it suggests screening in. Also, note that a response of "NO" to this "adequate characterization" question leads to a recommendation of "expeditious" collection of needed data. However, if the preliminary data indicates no unacceptable risks, it is unclear that a quick response is necessary. The Agency has created a perception that one needs more data than are typically available on a RCRA or Superfund site to adequately evaluate the vapor pathway. It is our experience that the combination of existing data and consideration of multiple lines of evidence may be sufficient to demonstrate whether this pathway should be of concern for BTEX sites. We recommend that the emphasis be placed on the examination of multiple lines of evidence, not a "gold standard" of data quality.

Section 2. Additional Comments and Technical Backup (Continued)

Guidance Section	Comment
Tier 1 – Primary Screening Question 1.	**Chemicals Included in Table 1** Table 1 should simply list chemicals that are screened in. Listing chemicals that are screened out adds no real value and makes the table unnecessarily complex.
Tier 1 – Primary Screening Question 3	**Criteria Warranting Immediate Action** In the explanatory text to this question, the Agency describes some qualitative criteria generally considered sufficient to indicate a need for immediate actions. These include odors and physiological effects that may be unrelated to the presence of subsurface contamination, as pointed out in the Agency's cautions on the importance of evaluating "background" as part of the overall evaluation. In this case, the explanatory text should indicate that the most appropriate action might be to investigate potential background sources for reported odors or physiological effects. The text accompanying the Yes checkbox should similarly indicate that investigation of "background" sources would also be an appropriate action to verify the imminent risk. Actions that focus on potential subsurface sources that do not address potential background sources are unlikely to solve the problems noted. Similarly, the explanatory text should advise readers to determine the possible causes of a wet basement as they are often the result of improper grading of soil around the house. **Engineering Controls** The Agency should add a sub-question that asks whether any buildings have vapor barriers or other engineered features that would make vapor entry from the subsurface unlikely.
Tier 1 – Primary Screening Question 2.	**Determining the Distance From a Plume That Should be Considered in the Screening** API supports the Agency's decision to suggest use existing definitions of groundwater plume boundaries (e.g., MCLs, State Standards or risk-based screening levels) to determine the distance from the contamination to buildings that should be screened. However, the Agency provides no defensible support for selecting 100 feet from the plume or contamination boundary as a criterion that is applicable to the biodegradable BTEX compounds. In fact, a study conducted by Groundwater Services, Inc. for API (see Section 3 of these comments) found that dissolved hydrocarbons in groundwater do not cause detectable impacts to indoor air. Therefore, the 100 foot distance from the plume is overly-conservative and should be dropped.

Section 2. Additional Comments and Technical Backup (Continued)

Guidance Section	Comment
Tier 2 – Secondary Screening General	**Pathway Completeness vs. Unacceptable Risk** The guidance should be modified to reflect that Q4 and Q5 screening do not evaluate whether a pathway is complete or incomplete, but whether or not conditions of unacceptable risk exist. Therefore the evaluator should be able to implement any reasonable means to reduce the risk. **Consideration of Horizontal Layers** The guidance suggests that the Q4/Q5 conceptual model accommodates horizontal layers of differing soil types when they are not actually addressed in these equations. In fact, the EPA vapor intrusion model/spreadsheet can consider this scenario. The Agency should explain why this scenario was not actually considered, in spite of the statement to the contrary. **Development of Tables 2 & 3 Used for Secondary Screening** See comments on Appendix D. **Precluding Factors** A single question regarding factors precluding the use of the guidance should be asked at the beginning of the process, not multiple times during the Secondary Screening. The factors that preclude the use of generic factors are arbitrary (especially the depth to groundwater criterion). The Agency should consider replacing the 5 ft to groundwater criterion with "very moist or saturated soils at the slab/foundation depth. The limitation on samples collected less than 5 ft below slab depth is restrictive. In many parts of the country, there is no other option. Does EPA have data to demonstrate that these samples (if collected properly) are of poor quality? Also, some of the criteria for the <15' to groundwater conditions may be precluding factors regardless of the depth (the screening values should not be used if site conditions to not match assumptions of the conceptual model for the calculations). Also, these precluding factors do not necessarily lead to enhanced advective transport (as suggested in the discussion at the bottom of page 27). These precluding factors need to be reconsidered. As an example of the application of precluding factors, the guidance should discuss whether the unsaturated natural soil conditions at the Colorado DOT site (often described as fractured silt stone) would be considered a precluding factor that prevents use of the guidance for evaluation of the site. If it would not be appropriate to apply the guidance to the Colorado DOT site, then Appendix F should include a discussion of why it was appropriate to include data from this site in the dataset used to select the default attenuation factors used in the guidance.
Tier 2 – Secondary Screening General Question 4	**Enhanced Convective Transport (4c)** The Agency should state explicitly that this is a chlorinated solvent-only issue and that it does not affect petroleum hydrocarbons. **Generic Attenuation Factors** Based on the analysis presented in Section 3 of API's comments, the Agency should calculate groundwater screening concentrations (Table 2) using a conservative upper-bound groundwater-to-indoor-air attenuation factor of 0.0001 rather than 0.001. This analysis also provides a basis for calculating subslab soil gas screening concentrations using a conservative upper-bound subslab-to-indoor air attenuation factor of 0.01 rather than 0.1.

Section 2. Additional Comments and Technical Backup (Continued)

Guidance Section	Comment
Question 4 Discussion Item 2, How should data be used in this question?	**Compound of Concern (COC) Detection** The guidance states that "If the detection limit for any constituent of potential concern is above its target level, we recommend continued evaluation as though the target level is exceeded." However, other EPA guidance acknowledges that no response action is required to address COCs that are not detectable using appropriate analytical methods. Therefore, it would be more appropriate to recommend that no further evaluation be conducted for a COC if it is not detected when analyzed using an appropriate method, regardless of the detection limit obtained.
Question 5	**Soil Gas profiles for Verification of Petroleum Vapor Attenuation** API recommends that the Agency specifically list hydrocarbon and oxygen soil gas profiling as a line of evidence to demonstrate site-specific attenuation of petroleum hydrocarbons of concern (specifically BTEX). It has been well documented that the presence of oxygen above or adjacent to a delineated source is sufficient evidence that petroleum hydrocarbon vapors are being attenuated. This is a reasonable approach to reduce the number of sites that continue to Question 6. **Use of Downgradient Groundwater Concentrations** Question 5(d) seems to imply that if your source is in the vadose zone, you can't use downgradient groundwater concentrations along with the screening tables (you have to have soil gas). This contradicts other statements in the guidance about including the 100' separation from the source to the downgradient point of interest in the groundwater.
Tier 3 – Site Specific Assessment	**Site-Specific Assessment for Bioattenuation.** The introductory section should include a discussion/reference to biodegradation. Details of site-specific data to collect to help evaluate biodegradation would be appropriate here.
Tier 3 – Site Specific Assessment Question 6	**General Approach** Since the Q5 target levels are not discriminating for petroleum hydrocarbons such as BTEX, many sites will fall into the Q6 analyses. As articulated, the Q6 analyses are supposed to be site-specific, but they are prescriptively described. It will be difficult to implement alternative approaches, regardless of their validity. The Q6 text should be more in-line with the text included in Q6 in the RCRA EI guidance. **Use of Through-Slab Sampling** The Agency is placing undue emphasis on through-slab and subslab sampling. Despite statements of EPA advocates of this method that homeowners welcome this approach, API is certain a majority of homeowners would like assessors to employ other valid sampling techniques before drilling through their slabs or basements. In addition to the possibility of damaging concealed utilities or impermeable liners, through-slab sampling requires consideration of the long-term maintenance of the penetrated floor. Finally, there is little professional experience with through-slab sampling to date. The Agency has not presented any evidence that through-slab sampling provides better data than other methods employed adjacent to a building for evaluating vapor pathway risk. API recommends that the Agency not require through-slab sampling (or any other monitoring method) in Question 6 **Question 6(c)** This question should be reworded as follows: "Are groundwater/soil gas concentrations below modeled protective values?" (The reason for this change is that this guidance is not to be used to calculate risk.) **Site-specific Sub Slab Attenuation Factors** It is unclear why site-specific sub-slab attenuation factors are not considered. It is possible to collect building ventilation data and/or Qsoil data to calculate a site-specific sub-slab attenuation factor. (See Johnson, 2002).

Section 2. Additional Comments and Technical Backup (Continued)

Section	Page	Comment
Appendix D: Development of Tables 1,2, & 3		**Clarification of Data Sources** Toxicity value sources include a HEAST Alternative (A), which is not currently defined in the text. A description of this source should be added. **Clarifications to Table D-1** The Agency should consider the following changes to improve the clarity of Table D-1: • The Agency should delete chemicals that do not meet the criteria for volatility and toxicity. • The solubility, Henry's Law coefficient, and maximum calculated vapor concentration values should be included on Table D-1. Current problems with the SCDM database do not allow users with the latest versions of the Windows operating system to access the database. Specifically, the user has to modify the AUTOEXEC.BAT file in order to run it. With the new Windows versions, the AUTOEXEC.BAT file has been conveniently hidden and is not available for modification. Including these parameter values on the tables would also make the guidance complete (self-contained). • Some of the toxicity values listed in the table are designated as "withdrawn" values by Regions III and IX. This designation should be noted in this table and the reasons for their withdrawal should be reviewed to determine whether they should, in fact, still be used at all. • The inclusion of NCEA provisional values in the table should be reconsidered. EPA Regions III and IX routinely use NCEA values as well, however there are some discrepancies between the values included in Table D-1 and those used by the regions. These discrepancies result in inconsistencies between screening levels used for the indoor air and other exposure pathways at the same site. For example, the regions include NCEA values for benzene, benzyl chloride, chloroform, 1,2-dichloroethane, and tetrachloroethene that are not included in Table D-1.
Apndx E	All	**Unsupported Sampling and Analysis Recommendations:** Appendix E of the Vapor Intrusion Guide presents detailed recommendations regarding sampling and laboratory methodologies and other related issues that have no scientific basis and are inappropriate in a general guide of this nature. Specific examples of such recommendations are identified in the further Appendix E comments provided below. Such unsupported statements conflict with more authoritative sampling and analytical guidelines and will inappropriately influence decision-making on numerous sites. Such statements represent only the opinions of the authors of this Appendix and are not suitable or technically defensible as EPA "recommendations" to be implemented at many sites across the nation. We strongly encourage the Agency to either delete Appendix E in its entirety or to limit the discussion to identification of other authoritative sources of information.

Section 2. Additional Comments and Technical Backup (Continued)

Section	Page	Comment
Apndx E	E-2	**Groundwater Sampling** The second paragraph under Section III of this Appendix recommends that groundwater samples be collected from wells screened at or across the top of the water table, rather than from wider screened monitoring wells, which may cause "in-well blending" and "negative bias" results. The authors of this text have apparently assumed that shallow water samples will provide the best prediction of indoor air impacts; however, this is not, in fact, supported by actual site data. For example, at the Raymark Industries site in Stratford, Connecticut, EPA researchers found a poor correlation between soil vapor concentrations and shallow groundwater samples, with groundwater representing a broader section of the groundwater unit providing a better prediction of soil vapor levels in the overlying vadose zone (DiGiulio, 2003). The recommendation regarding the need for groundwater samples collected across a "narrowly screened interval across the groundwater table" should be deleted as it is neither based upon nor supported by factual data. Referenced ASTM methods for groundwater sampling should be summarized instead of referenced in their entirety because of potential conflicts with current Agency practices or current efforts to characterize the vapor intrusion pathway.
Apndx E	E-4	**Proactive Remediation** In the first paragraph under Section IV of this Appendix, the guide recommends that consideration should be given to "proactive exposure controls, which may be cost-competitive" with air sampling efforts. In the absence of any evidence of a vapor intrusion impact, it is unreasonable and impractical to install a "proactive exposure control." Nor is there any factual basis to suggest that such measures would indeed be "cost-competitive" with sampling at most sites. Given the expected use of this guide for many remediation sites across the nation which are likely, in fact, to have no vapor intrusion impacts, the Agency should reconsider "recommendations" of this nature. Statements regarding remediation measures should be deleted from this Appendix, which is designed to address sampling and analytical methodologies.

Section 2. Additional Comments and Technical Backup (Continued)

Section	Page	Comment
Apndx E	E-5 to E-6	**Indoor Air Sampling: Sampling Guidelines** Page E-5 of the guide offers several unfounded recommendations regarding sample collection and analysis which are both inappropriate and impractical for the purpose of collecting representative indoor air samples. Key points in this regard include: • *Sealing of the Indoor Space*: The text recommends that the "house be closed" 12 to 24 hours before sample collection, including shutting down of appliances that may induce negative pressure gradients. Such measures are not only impractical for most occupied structures, but would result in non-representative sample collection in all cases. In those cases where negative pressure gradients are normally present, these measures would under-estimate actual vapor intrusion levels. • *Analytical Method Detection Limits*: The text recommends that the TO-15 and TO-17 methods be "appropriately modified" to provide a detection limit "considerably below 0.5 ppbv." For many site conditions, it is not practical to achieve such detection limits using these methods. It is furthermore inappropriate for this guide to recommend that standard analytical methods be "modified" for this purpose. Because the expected background indoor air concentration will typically be greater than 0.5 ppbv (see TO-15 and TO-17 methods), the purpose of modifying the detection limit is unclear. • *Multiple Replicate Sampling*: The text recommends that "multiple simultaneous samples" be collected for each sampling event and "from the same inlet so that variability in nominally identical samples can be documented." This recommendation is not set forth in the EPA "Compendium of Methods for the Determination of Air Pollutants in Indoor Air," the EPA 1991 or the OSHA 1999 guidance documents on indoor air investigation, and there is no reasonable scientific basis for imposing this very costly "recommendation" in this Vapor Intrusion Guide. • *Water Vapor and Ozone Analyses*: The text further departs from established sampling guidelines to recommend that "preliminary experiments be conducted to document the effects of water vapor levels on analytical performance" and that the "ozone concentration be determined at every sampling event." The effect of water vapor on sorbent cartridge performance is well established and need not be re-examined at each sampling event. There is no agreed upon basis for interpretation of ozone measurements, and this data would therefore serve no purpose with regard to interpretation of VOC results. API strongly recommends that each of these "recommendations" be deleted from the guide. The Vapor Intrusion Guidance should conform to the specifications set forth in more authoritative texts. In order to ensure consistency in application of analytical and measurement methods across the various regulatory frameworks, recommendations to modify these methods should be made only through revision of the original source documents.
Apndx E	E-4	**Indoor Air Sampling: Source Survey** In the second paragraph of Section IV, the text recommends that a preliminary survey be conducted "to adequately identify the presence of any possible indoor air emission sources of … target VOCs." As acknowledged in both EPA and OSHA indoor air sampling guidelines, numerous sources of VOCs are nearly always present within occupied indoor spaces; consequently, a survey of such sources is not conclusive regarding the absence of such sources. Such a survey may be useful identifying a fraction of potential indoor air sources, however, no data currently exists concerning the ability of a survey to identify the most significant sources in a building. If retained, this text should be modified to clarify that all modern buildings are expected to contain sources of volatile chemicals, many of which cannot be removed. An absence of specific identified sources should not be taken as an indication that background sources are unimportant.

Section 2. Additional Comments and Technical Backup (Continued)

Section	Page	Comment
Apndx E	E-5	**Indoor Air Sampling: Number of Sampling Events** In the third paragraph on page E-5, the text recommends two or more sampling events at each location. At various training sessions, EPA staff have implied that a minimum of four sampling events would be required to characterize indoor air concentrations. Currently, only very limited data are available concerning the temporal variation in indoor air concentrations. At this time, it is premature to provide specific recommendations concerning the number of indoor air sampling events required. This determination should be made based on a site-specific evaluation. At some sites, a single "worst-case" indoor air sampling event (e.g., during cold weather resulting in negative building pressure) may be sufficient to demonstrate that no indoor air impact has occurred.
Apndx E	E-6 to E-7	**Reliability of Soil Gas Sampling Results** The opening statements of Section V indicate that soil gas sampling is less reliable in "lower permeability settings and when sampling shallow soil gas." Again, although this statement may represent the opinion of the authors, there is, in fact, no basis in actual scientific data for the suggestion that soil gas sampling from lower permeability soils or shallow depths (i.e., less than 5 feet below ground surface) is not "reliable" as a predictor of indoor air impacts. There are a variety of appropriate methodologies for soil gas sampling in lower-permeability soils and at shallow soil depths (e.g., soil flux chambers), and there is no factual basis for a blanket statement categorizing these methodologies as unreliable. There is, furthermore, no data showing that sampling at depths of greater than 5 feet below ground surface or "several feet in from the edge" of the foundation is necessary to obtain "reliable" results. Nor is it necessary or practical in all cases to measure a vertical soil gas profile beneath the structure or to collect oxygen, nitrogen, and carbon dioxide gas samples, as, quite simply, the mere absence of VOC vapors in the shallow soil horizon precludes vapor impacts on the overlying structure. Finally, the text also recommends a "minimum purge volume" so as to "avoid dilution" – a recommendation which again has no technical foundation and directly conflicts with the EPA guidelines currently under development for subslab sampling. The unfounded opinions presented as "recommendations" in this guide are not suitable or technically defensible as EPA recommendations and should be deleted. **Other Analytes** The added benefits of sampling O_2, CO_2, N_2 and inclusion of CH_4 should also be addressed. For example O_2, CO_2, CH_4 data can be used as line of evidence for biodegradation. This is a significant omission. These data also can be used to help assess whether a vacuum was created during sample collection, which would significantly affect the vapor concentration measurment. [The sum of partial pressures (pp) of all the fixed and non-fixed gases (O_2, CO_2, N_2 , CH_4, VOCs) should add up to 1 (i.e., under atmospheric conditions, $ppO_2 = 0.21$, $ppN_2 = 0.79$).]
Apndx E	E-7	**Subslab Soil Gas Sampling** Technical guidance for through-slab soil gas sampling is currently under development by the Agency, and it is inappropriate for Appendix E of the Vapor Intrusion Guide to provide detailed recommendations on this topic, particularly as the statements made herein directly conflict with the more authoritative forthcoming guidance. In particular, detailed specifications of "3 to 5" sampling points with "9/16-inch" diameter should be deleted. In addition, the long discussion regarding sampling from the soil "subsidence zone" beneath the floor slab is both impractical and unnecessary. It is impractical to suggest that "when drilling the hole, care should be taken not to puncture the surface of the underlying soil." Furthermore, normal activities such as operation of household appliances "such as exhaust fans, clothes dryers… or roof-mounted attic fans" will in no way serve to "disturb the subslab region." Even if such activities could affect subslab vapors (which is difficult to imagine in any case except a crawl space receiving direct exhaust fan discharge), normal activities should nevertheless be maintained so as to obtain representative samples. Again, the recommendations presented herein represent unfounded opinion and are unsuitable for release as EPA technical recommendations.

Section 2. Additional Comments and Technical Backup (Continued)

Section	Page	Comment
Apndx E	E-8	**Slam Bar Methods** For application of this sampling technique, the text recommends that a minimum purge volume be extracted from the sample device in order to avoid surface air leakage. Again, no scientific data are available to support such a recommendation with regard to a properly sealed sampling device, and this statement furthermore directly conflicts with the purge volume recommendations proposed for the forthcoming EPA subslab sampling guidance. Such unfounded opinion is not suitable for inclusion in this guide.
Apndx E	E-8	**Soil Sampling** Some important facets of soil sampling are downplayed. API agrees that there is considerable variability in soil chemical analyses; however, the wealth of information that can be obtained by screening soils using a PID or by assessing grain size (soil type), moisture content, total porosity cannot be underestimated. This information is useful for helping complete the site conceptual model and helping design or interpret the soil gas investigation.
Apndx E	E-8 to E-9	**Other Issues** Section VII of the text contains the unfounded statement that VOCs at non-detectable concentrations in groundwater may be detectable in the soil gas. Although application of theoretical equilibrium relationships might suggest that such a condition could exist, actual field data do not support this assumption. In fact, actual field data from numerous sites show that soil gas concentrations do not achieve these theoretical equilibrium levels. Over the years, numerous parties have suggested soil gas sampling as a method for cost effective delineation of groundwater plumes. However, this approach has proved to be unreliable due to the poor correlation between groundwater and soil gas concentrations. This unfounded statement leads to the inference that soil gas sampling may be appropriate even when groundwater concentrations are non-detectable, which is absurd. Again, statements of this nature must be deleted from this guide as they are technically unsound and highly misleading.
Apndx F	All	**Analysis of the USEPA Vapor Intrusion Database** Background indoor air sources have a clear and significant impact on the indoor air concentration data in the EPA Vapor Intrusion Database. The analysis of this database presented in Appendix F does not adequately account for the impact of background indoor air sources on the measured attenuations factors. As a result, the upper-bound groundwater and subslab attenuation factors selected for development of groundwater and soil gas screening concentrations are not supported by the available data and dramatically over-predict vapor intrusion even at reasonable worst-case sites. Additional detail on our analysis of the EPA Vapor Intrusion Database is provided in the following comments and in Section 3 these comments.
Apndx F	All	**Use of Maximum Indoor Air Concentrations in Database** Most of the indoor air concentrations in the database are maximum values from multiple measurements. In contrast, the risk-based exposure limits are intended to be average exposure concentration limits. The use of maximum indoor air concentrations results in a conservative bias in the attenuation factors that is not clearly documented in Appendix F or in slide presentations describing development of the database. The magnitude of the conservative bias introduced by use of maximum indoor air concentrations is difficult to assess without access to the full range of indoor air measurements for each site. Development of conservative values for pathway screening is appropriate, however, the conservatism should always be documented and should be quantified when possible.
Apndx F	All	**Site Bias in Database** The data in the Vapor Intrusion Database has been collected from sites that have known or suspected vapor intrusion problems. These sites are likely to have less vapor attenuation compared to typical corrective action sites. As a result, the average attenuation factor for the population of sites in the database would be conservative if applied to the general population of corrective action sites. The magnitude of this conservative bias will be difficult to quantify, but should be acknowledged in Appendix F.

Section 2. Additional Comments and Technical Backup (Continued)

Section	Page	Comment
Apndx F	All	**Attenuation Factor for Petroleum Hydrocarbons** The available data indicate that petroleum hydrocarbons such as BTEX in groundwater do not cause a measurable indoor air impacts. The indoor air concentrations of BTEX in the EPA Vapor Intrusion Database are completely within the range of background indoor air concentrations for these chemicals, as reported in the literature. In addition, no correlation is observed between concentration in groundwater and concentration in indoor air. These observations are consistent with literature reports of the rapid biodegradation of petroleum hydrocarbons in unsaturated soils. As stated previously, based on the available evidence that dissolved petroleum hydrocarbons in groundwater do not cause measurable indoor air impacts, API recommends that BTEX should be removed from the Vapor Intrusion Guidance. API feels strongly that the Agency is unreasonably discounting the evidence for biodegradation of petroleum hydrocarbons, such as BTEX, in the unsaturated zone. Rather than assuming biodegradation of petroleum hydrocarbons in the unsaturated zone is *not* occurring, the approach should be to assume it *is* occurring unless other lines of evidence suggests it is not. Here are but a few references supporting our position: Roggemans, S., C.L. Bruce, P.C. Johnson, and R.L. Johnson. 2001. Vadose Zone Natural Attenuation of Hydrocarbon Vapors: An Empirical Assessment Of Soil Gas Vertical Profile Data. API Soil and Groundwater Technical Task Force Bulletin No. 15. December 2001. DeVaull, G. E., R. A. Ettinger, J. P. Salanitro, J. B. Gustafson. 1997. Benzene, Toluene, Ethylbenzene and Xylenes (BTEX) Degradation in Vadose Zone Soils During Vapor Transport. Proceedings. Petroleum Hydrocarbons and Organic Chemicals in Groundwater: Prevention, Detection and Remediation. Houston, Texas. Jury W.A.,D. Russo, G. Streile, and H. Elabd. 1990. Evaluation of Volatilization by Organic Chemicals Residing Below The Soil Surface, Water Resources Research, 26, (1), 13-20. M.L. Fischer, A. J. Bentley, K. A. Dunkin, A. T. Hodgson, W. W. Nazaroff, R. G. Sextro, and J. M. Daisey. 1996. Factors Affecting Indoor Air Concentrations of Volatile Organic Compounds at a Site of Subsurface Gasoline Contamination. Environmental Science & Technology. 30(10), 2984-2957. Jin, Y., T. Streck, and W. A. Jury, 1994. Transport And Biodegradation of Toluene in Unsaturated Soil. *J. Contamin. Hydrol* , 17(2):111-127. Hers, I., R. Zapf-Gilje, L. Li, J. Atwater. 2000. Canadian Consortium Research Project Validation of Models Used to Predict Indoor Air Quality from Soil and Groundwater Contamination. Proceedings. Petroleum Hydrocarbons and Organic Chemicals in Groundwater: Prevention, Detection and Remediation. Anaheim, CA. p. 213. Hers, I., R. Zapf-Gilje, L. Li, J. Atwater. 2001. Use of Indoor Air Measurements to Evaluate Intrusion of Subsurbace VOC Vapors into Buildings. *J. of Air and Waste Mng. Assoc.* 51:1318-1331.

Section 2. Additional Comments and Technical Backup (Continued)

Section	Page	Comment
Apndx F	F-2	**Groundwater-to-Indoor-Air Attenuation Factor** The EPA analysis conducted to develop the upper-bound groundwater-to-indoor-air attenuation factor does not adequately account for background indoor air sources. API has utilized three different approaches to reduce the impact of indoor air background on measured attenuation factors: i) analysis of data points with groundwater concentration greater than 1000 ug/L, ii) analysis of 1,1-DCE data, and iii) regression analysis to estimate the average true attenuation factor and the average background concentration for sites in the database. All three methods of analysis support the selection of 0.0001 (rather than 0.001) as a conservative upper-bound groundwater-to-indoor-air attenuation factor. API recommends that 0.0001 is used as the conservative upper-bound attenuation factor for generation of groundwater screening concentrations used in Question 4 of the guide.
Apndx F	F-2	**Use of Henry's Law to Calculate GW to IA Attenuation Factors** Because diffusion through air is about 10,000x faster than diffusion through water, diffusion from bulk groundwater to the bottom of the capillary fringe should be the rate limiting step for groundwater-to-indoor-air vapor intrusion. If this is the case, then volatilization from groundwater to indoor air should not be proportional to the Henry's Law constant. In addition, Barber et al. (1990) report that soil gas concentration above the water table will be independent of the Henry's Law constant for volatile chemicals and H' greater than 0.01. The inclusion of Henry's Law constant in calculation of groundwater-to-indoor-air attenuation factors has the potential to artificially increase the range of attenuation factors observed for a site. API recommends that the Agency consider the calculation of groundwater-to-indoor-air attenuation factors as C_{ia}/C_{gw} rather than $C_{ia}/(C_{gw} \times H')$ for volatile chemicals with a Henry's Law constant (H') greater than 0.01.
Apndx F	F-3	**Subslab-to-indoor-air Attenuation Factor** The Lowry Air Force Base data set appears to be heavily influenced by background indoor air impacts with 21% of indoor air concentrations greater than the corresponding subslab concentrations. The EPA analysis conducted to develop the upper-bound subslab-to-indoor-air attenuation factor does not adequately account for background indoor air sources. Three alternative analyses support the selection of an upper bound attenuation factor of 0.01 (rather than 0.1): i) analysis of data points with a subslab concentration greater than 100 ug/m^3, ii) review of observed radon attenuation factors, and 3) analysis of the default attenuation factor from the EPA Johnson Ettinger Spreadsheet. API recommends that 0.01 is used as the conservative upper-bound attenuation factor for subslab-to-indoor-air attenuation.
Apndx F	F-4	**Reliability Assessment** The reliability assessment conducted to evaluate the utility of the Table 2 and Table 3 screening values for correctly predicting indoor air impacts is not meaningful. Because the indoor air limit for many carcinogens is significantly below typical background indoor air concentrations, many of the indoor air exceedances identified as "correct positives" in the reliability assessment are clearly associated with background sources rather than vapor intrusion from groundwater. API recommends that the reliability assessment should be removed from the Vapor Intrusion Guidance.
Apndx G	All	**Application of the Johnson and Ettinger (1991) Model** The Agency has overlooked a unique reference regarding the use of the Johnson and Ettinger model (JEM): Johnson, P.C., 2002. *Identification of Critical Parameters for the Johnson and Ettinger (1991) Vapor Intrusion Model.* (Downloadable from www.api.org/bulletins) This paper contains numerous tips on application of the model and parameter selection for site-specific applications.
Apndx G	G-2	**Precluding the Use of the JEM in the Presence of NAPL** The presence of NAPL (especially DNAPL) should not preclude the use of the JEM. The EPA version of the guidance explicitly states that it can handle this condition. In the preface of the new guidance, it states that soil sources with NAPL can be evaluated. Soil gas samples can be collected above the NAPL and an assessment can be made.

Section 2. Additional Comments and Technical Backup (Continued)

Section	Page	Comment
Apndx G	G-2	**Precluding the Use of the JEM in the Presence of Large Groundwater Fluctuations** The Agency implies that the capillary fringe will be further contaminated in the presence of a fluctuating water table. The Agency should reconsider it restriction because: 1) if there was no mobile NAPL, the capillary fringe will be as contaminated as previously (or very close), and 2) one can just use the model with the distance from the foundation to the highest groundwater elevation.
Apndx G	Table G-1	**Aqueous Phase Diffusion** In Table G-1, one of the assumptions states that the JEM as implemented by EPA does not consider diffusion in the aqueous phase. To the contrary, the EPA JEM manual says that the Millington-Quirk relationship is used to calculate diffusion and it includes the water phase diffusion for both the unsaturated zone and the capillary fringe.
Apndx G	Table G-2	**Parameter Sensitivity** In Table G-2, it states that the JEM has low sensitivity to changes in porosity values and moderate to high sensitivity to changes in moisture content. These parameters are not independent as pointed out in Johnson (2002) (referenced above). If one has high sensitivity, the other has high sensitivity. The parameters moisture content and total porosity shouldn't be evaluated separately, what matters is the moisture saturation which is: $S_m = \frac{\theta_w}{\theta_T}$
Apndx G	G-6	**Building Mixing Heights** Different building mixing heights are proposed for slab-on-grade vs. basement scenarios. This discrepancy should be clarified or resolved.
Apndx G	G-7	**Soil Gas Entry Rate** The Agency specifies a Q_{soil} equal to 5 L/min no matter what size the house is. This is problematic because larger houses have higher volume of fresh air exchange. The Q_{soil} should be tied to the square foot area of the foundation or basement walls. Another way to do that however is to use a combined parameter: Q_{soil}/Q_B as discussed in Johnson (2002). In this approach, when the square foot area of the house increases, the soil gas entry rate increases as well. As pointed out in Johnson (2002) it is easier to obtain better information for the ratio than Q_{soil} on its own.
Apndx G	G-8	**Use of the JEM as a Site-Specific Model** The Agency recommends that one uses a calibrated model if one dosen't meet all of their criteria for applying the JEM otherwise. However, if one has a calibrated model (i.e., calibrated to indoor air concentrations), 1) one doesn't need to model the situation and 2) the model will likely be wrong because of ambient contaminant contributions to indoor air. Possibly a better way to use the model in tough situations is to calibrate it from one section in the unsaturated zone to another (e.g. from groundwater to sub-slab concentrations or other soil gas concentrations directly above the source). This approach eliminates the ambient indoor air problems and also produces a model that can be used in a predictive manner in another location that has the same soil/site characteristics (e.g. under houses where one has not sampled or for future development).

Section 2. Additional Comments and Technical Backup (Continued)

Section	Page	Comment
Apndx I	All	**Unsupported Recommendations** This appendix provides recommendations for addressing background indoor air sources with little or no data available to indicate whether these recommendations would be effective. For example, there is not scientific data to indicate whether background sources of indoor air impacts can be accurately identified through site inspection and whether removal of suspected indoor air sources will definitely reduce background indoor air concentrations in homes. "Recommendations" which represent the opinions of the authors and are not supported by the scientific literature should be removed from the guide.

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SECTION 3: DETAILED EVALUATION OF USEPA VAPOR INTRUSION DATABASE

API Comments on USEPA Vapor Intrusion Guidance

This attachment provides additional detail concerning API comments on the USEPA Vapor Intrusion Database and the evaluation of the database presented in Appendix F of the Vapor Intrusion Guidance. This attachment addresses the following issues:

- The importance of background indoor air sources on measured attenuation factors
- Alternative methods to determine an upper-bound groundwater-to-indoor-air attenuation factor
- Alternative methods to determine an upper-bound subslab-to-indoor-air attenuation factor
- Vapor intrusion associated with petroleum hydrocarbons
- Reliability Assessment for groundwater screening concentrations

Based on our analysis of the database, we recommend the following changes to the Vapor Intrusion Guidance:

1) <u>Groundwater-to-Indoor-Air Attenuation Factor</u>: Calculate groundwater screening concentrations using a conservative upper-bound attenuation factor of 0.0001 rather than 0.001.

2) <u>Subslab-to-Indoor-Air Attenuation Factor</u>: Calculate subslab soil gas screening concentrations using a conservative upper-bound attenuation factor of 0.01 rather than 0.1.

3) <u>Petroleum Hydrocarbons</u>: Eliminate petroleum hydrocarbons from the Vapor Intrusion Guidance. Provide separate guidance for petroleum hydrocarbons vs. chlorinated solvents rather than UST sites vs. other corrective action sites.

4) <u>Reliability Assessment</u>: Remove the reliability assessment from the Vapor Intrusion Guidance or modify the assessment to accurately reflect that the use of conservative upper-bound attenuation factors will necessarily result in false positive indications of vapor intrusion at many sites.

The basis for these recommendations is provided below.

IMPORTANCE OF BACKGROUND INDOOR AIR SOURCES ON MEASURED ATTENUATION FACTORS

Background indoor air sources have a significant impact on the measured groundwater-to-indoor-air and subslab-to-indoor-air attenuation factors. Graphs of the measured attenuation factor vs. the measured source concentration show that the attenuation factor decreases dramatically with increasing source concentration (Figure 1). This trend is explained by the influence of background indoor air sources on the measured attenuation factor because background indoor air sources have the largest effect on the measured attenuation factor at low groundwater concentrations. For example, at a site with a true attenuation factor of 0.0001 and a background indoor air concentration of 10 ug/m^3, if the groundwater concentration is 1 ug/L, the measured attenuation factor will be 0.0101 (101 times greater than the true attenuation factor). However, if the groundwater concentration is 1000 ug/L, the measured attenuation factor will be 0.00011 (only 10% higher than the true attenuation factor).

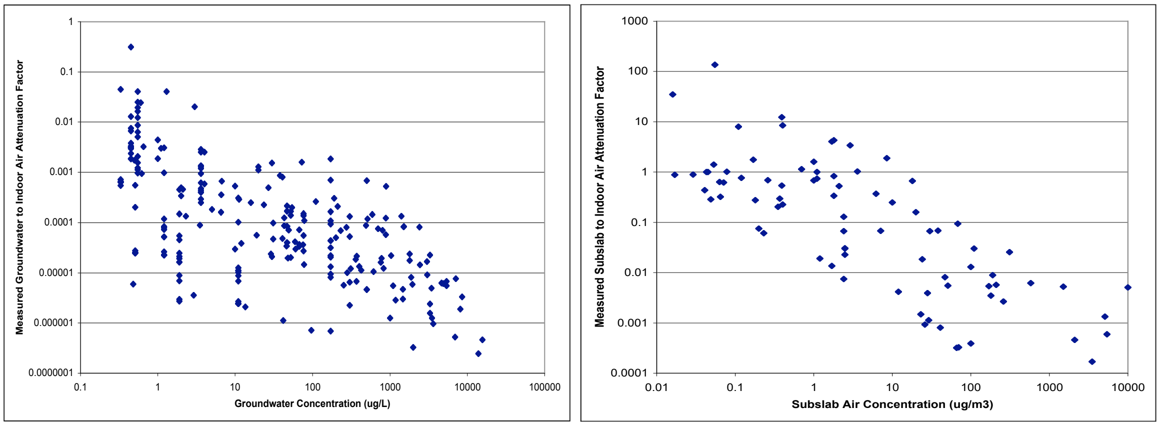

Figure 1. Correlation Between Source Concentration and Measured Attenuation Factor: Negative Correlation Indicates Impact of Background Sources on Measured Attenuation Factors.

In the analysis of the Vapor Intrusion Database presented in Appendix F of the Vapor Intrusion Guidance, the USEPA attempted to reduce the impact of background indoor air sources on the measured attenuation factors by eliminating data points with an indoor air concentration below the geometric mean of average background indoor air concentrations reported in the literature. Although this resulted in the removal of 107 out of 208 data points (more than half of the database), the remaining data points still show a strong negative correlation between groundwater concentration and measured attenuation factor, indicating that background indoor air impacts have a strong influence on the measured indoor air concentration (Figure 2).

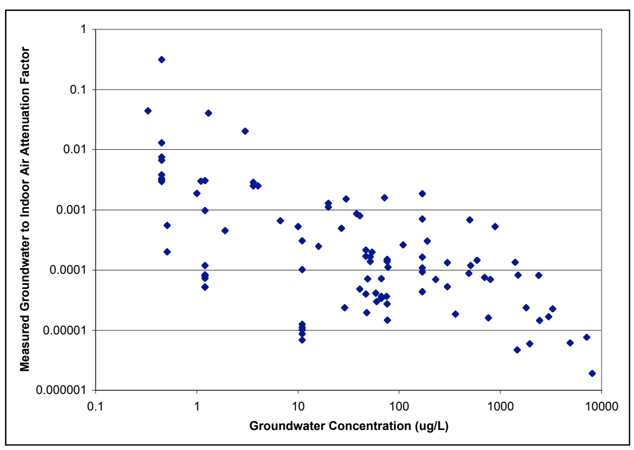

Figure 2. Effect of Removing Data Points with Below Average Indoor Air Concentrations on the Distribution of Measured Attenuation Factors: Background Indoor Air Sources Still Impact Measured Attenuation Factors

It should be noted that the distribution of indoor air concentrations in the Vapor Intrusion Database is completely consistent with background indoor air concentrations in the absence of vapor intrusion (i.e., more than half of the indoor air concentrations are below the average background concentration reported in the literature). Thus, removal of data points with below average indoor air concentrations may simply serve to focus the analysis on the 50% of households with above average background indoor air concentration that would be expected within any dataset even in the absence of vapor intrusion.

Conclusion: Background indoor air sources have a large impact on the measured attenuation factors obtained from the Vapor Intrusion Database. The USEPA approach for decreasing the impact of background indoor air sources does not appear to have been effective.

ALTERNATIVE METHODS TO DETERMINE AN UPPER-BOUND GROUNDWATER-TO-INDOOR-AIR ATTENUATION FACTOR

Three approaches have been used to minimize the impact of background indoor air sources on the measured groundwater-to-indoor-air attenuation factors: 1) analysis of attenuation factors for data points with high groundwater concentrations, 2) analysis of attenuation factors for 1,1-dichloroethene, and 3) regression analysis to separate average background and true attenuation factors. All three approaches support the selection of 0.0001 (rather than 0.001) as a conservative upper-bound groundwater-to-indoor-air attenuation factor for the development of groundwater screening concentrations.

Analysis of Attenuation Factors for Data Points with High Groundwater Concentrations: The impact of background indoor air sources on the measured attenuation factor will be smallest at sites with high groundwater concentrations. For example, at a site with a true attenuation factor of 0.0001 and a background indoor air concentration of 10 ug/m^3, if the groundwater concentration is 1 ug/L, the measured attenuation factor will be 101 times greater than the true attenuation factor. However, if the groundwater concentration is 1000 ug/L, the measured attenuation factor will be only 10% higher than the true attenuation factor. Thus, analysis of sites with high groundwater concentrations should provide a better indication of the distribution of true groundwater-to-indoor-air attenuation factors at corrective action sites. Analysis of data points with a groundwater concentration greater than 1000 ug/L indicates that 0.0001 is a conservative upper-bound groundwater-to-indoor-air attenuation factor (Table 1).

Analysis of Attenuation Factors for 1,1-Dichloroethene: The background indoor air concentration of 1,1-dichloroethene is widely considered to be lower than that of many other common volatile groundwater contaminants. As a result, measured 1,1-dicholorethene attenuation factors should be less impacted by background indoor air sources than measured attenuation factors for other chemicals. Analysis of 1,1-dichloroethene data indicates that 0.0001 is a conservative upper-bound groundwater-to-indoor-air attenuation factor (Table 1).

It should be noted, however, that background indoor air sources or measurement errors likely have some impact on measured 1,1-dichloroethene attenuation factors. Average background indoor air concentrations of 1,1-dichloroethene have been reported to be as high as 6.5 ug/m^3 (MADEP, 1998). In addition, elevated concentrations of 1,1-dichloroethene have been reported is houses clearly not impacted by vapor intrusion at both the Colorado DOT site and the Redfield site. These houses were far removed from the dissolved groundwater plume and other potential subsurface sources. Although these elevated concentrations have been attributed to measurement error, this type of error likely also impacts the observed distribution of measured attenuation factors at sites located above 1,1-dichloroethene plumes. However, measurement errors are less likely to be discovered in buildings located above groundwater plumes or other subsurface sources.

Table 1. Distribution of Measured Attenuation Factors for Subsets of Data in the USEPA Vapor Intrusion Database.

	Measured Attenuation Factor		
	All Data	**Groundwater Concentration >1.0 mg/L**	**1,1-DCE Data**
Maximum	3.1E-01	1.3E-04	3.0E-03
95th Percentile	7.0E-03	**1.0E-04**	7.0E-04
75th Percentile	6.4E-04	1.5E-05	**1.0E-04**
50th Percentile	7.6E-05	5.7E-06	3.2E-05
Number of Data Points	255	34	48

Use of Regression Analysis to Estimate Average True Attenuation Factor: At corrective action sites where volatile chemicals in groundwater are causing an indoor air impact, the total measured concentration in indoor air will be equal to the background indoor air concentration plus the contribution from the groundwater. Although the relative contribution from background indoor air sources and from groundwater cannot readily be determined for an individual site, the average contributions from each source (i.e., background and groundwater) can be estimated for the population of sites in the database as described below.

The relationship between the groundwater and indoor air concentration is commonly expressed in terms of an attenuation factor (as defined in the USEPA Vapor Intrusion Guidance), as follows:

$$AF_{measured} = \frac{C_{ia}}{C_{gw} \cdot H'} \quad (1)$$

Where $AF_{measured}$ is the measured attenuation factor, C_{ia} is the measured indoor air concentration, C_{gw} is the measured groundwater concentration, and H' is the dimensionless Henry's Law constant. However, the measured indoor air concentration is the sum of the background indoor air concentration and the contribution from groundwater:

$$C_{ia} = C_{bk} + C_{gw-to-air} \quad (2)$$

Where C_{bk} is the background indoor air concentration in the absence of a contribution from groundwater, and $C_{gw\text{-}to\text{-}air}$ is the indoor air concentration due to migration from groundwater in the absence of a contribution from background indoor air sources. Assuming Henry's Law equilibrium between groundwater and deep soil gas, the indoor air concentration due to groundwater can be expressed as a function of groundwater concentration as:

$$C_{gw-to-air} = \left(C_{gw} \cdot H'\right) \cdot AF_{true} \quad (3)$$

where AF_{true} is the true groundwater-to-indoor-air attenuation factor. Substituting Equations 2 and 3 into Equation 1 yields:

$$AF_{measured} = \left(\frac{C_{bk}}{C_{gw} \cdot H'}\right) + AF_{true} \quad (4)$$

Equation 4 has the standard form of the slope, intercept equation for a line (i.e., y = m x + b). As a result, regression analysis of the measured attenuation factor verses $1/C_{gw}$ can be used to estimate the relative contribution of background (C_{bk}) and groundwater (AF_{true}) on the measured indoor air concentrations in the Vapor Intrusion Database.

The regression analysis indicates that background indoor air sources are a significant contributor to measured indoor air impacts. As shown in Table 2, the average background concentration for individual petroleum hydrocarbons for this data set is 58.5 ug/m^3 and the average background indoor air concentration for individual chlorinated solvents is 4.1 ug/m^3. These background concentrations are somewhat higher than the typical background concentrations reported in the literature (see Table F-1 from the Vapor Intrusion Guidance), however, this may be attributable to the fact that each indoor air value in the USEPA database represents a maximum indoor air concentration for a building based on multiple measurements. The average true attenuation factors are 4.0×10^{-5} and 1.7×10^{-4} for petroleum hydrocarbons and chlorinated solvents, respectively. However, for both chlorinated solvents and petroleum hydrocarbons, the true attenuation factor is not significantly different from zero, indicating that, for this data set, the groundwater-to-indoor-air pathway does not contribute to a statistically significant increase in indoor air concentrations compared to background conditions.

For both petroleum hydrocarbons and chlorinated solvents, the regression analysis yields poor R^2 values (0.54 and 0.03, respectively). These poor fits are expected, because the regression model used to determine the average background and true attenuation factor values does not account for the site-specific variations in the parameter values. Therefore, the regression model can account for only a limited amount of the variability in the data set. As discussed above, however, the regression estimates for average background (C_{bk}) for petroleum hydrocarbons and chlorinated solvents are statistically different from zero, indicating that the regression model does explain a statistically significant portion of the data set variability despite the low R^2 values. This regression analysis indicates that 0.0001 is a conservative upper-bound groundwater-to-indoor-air attenuation factor for chlorinated solvents.

Table 2. Best-Fit Estimates of Indoor Air Background and True Attenuation Factors

Chemical Class	**Average Background Concentration (1)**	**Average True Attenuation Factor (1)**	**Regression Coefficient (R^2)**
Petroleum Hydrocarbons (35 Cases)	58.5 ug/m^3 ($p<0.001$)	4.0×10^{-5} ($p=0.51$)	0.54
Chlorinated Solvents (220 Cases)	4.1 ug/m^3 ($p=0.007$)	1.7×10^{-4} ($p=0.92$)	0.03

1) Parameter values are for individual (not total) chemical concentrations within the chemical class. The p value is the statistical probability that the estimated parameter value is not different from zero (i.e., $p \leq 0.05$ is considered statistically significant).

Conclusion: Three different methods to reduce the impact of background indoor air sources on the measured groundwater-to-indoor-air attenuation factors in the USEPA Vapor Intrusion Database all support the selection of 0.0001 (rather than 0.001) as a conservative upper-bound groundwater-to-indoor-air attenuation factor for use in the development of groundwater screening concentrations for chlorinated solvents.

ALTERNATIVE METHODS TO DETERMINE AN UPPER-BOUND SUBSLAB-TO-INDOOR-AIR ATTENUATION FACTOR

Three approaches have been used to minimize the impact of background indoor air sources on the measured subslab-to-indoor-air attenuation factors: 1) analysis of attenuation factors for data points with high subslab soil gas concentrations, 2) analysis of radon attenuation factors, and 3) consideration of the attenuation factor implied by the USEPA Johnson Ettinger Spreadsheet default input parameters. All three approaches support the selection of 0.01 (rather than 0.1) as a conservative upper-bound subslab-to-indoor-air attenuation factor for the development of subslab soil gas screening concentrations.

<u>Analysis of Attenuation Factors for Data Points with High Subslab Soil Gas Concentrations</u>: The impact of background indoor air sources on the measured attenuation factor will be smallest at sites with high subslab soil gas concentrations. For example, at a site with a true attenuation factor of 0.01 and a background indoor air concentration of 1 ug/m^3, if the subslab soil gas concentration is 10 ug/m^3, the measured attenuation factor will be 11 times greater than the true attenuation factor. However, if the subslab concentration is 100 ug/m^3, the measured attenuation factor will be only 2 times the true attenuation factor. Thus, analysis of sites with higher subslab soil gas concentration should provide a better indication of the distribution of true subslab-to-indoor-air attenuation factors at corrective action sites. Analysis of data points with a subslab soil gas concentration greater than 100 ug/m^3 indicates that 0.01 is a conservative upper-bound groundwater-to-indoor-air attenuation factor (Table 3).

Table 3. Distribution of Measured Subslab-to-indoor-air Attenuation Factors for Subsets of Data in the USEPA Vapor Intrusion Database

	Measured Attenuation Factor	
	All Data	**Subslab Concentration >100 ug/m^3**
Maximum	140 (1)	0.030
95th Percentile	8 (1)	0.025
75th Percentile	0.80	0.0089
50th Percentile	0.14	0.0052
Number of Data Points	81	16

1) Measured attenuation factors greater than 1 occur when the indoor air concentration is greater than the subslab concentration.

<u>Analysis of Attenuation Factors for Radon</u>: The background indoor air concentration of radon is widely considered to be insignificant compared to the contribution from soil gas in high radon areas. As a result, measured radon attenuation factors should be less impacted by background than measured attenuation factors for volatile chemicals. Little et al., (1992) report that the average soil gas-to-indoor-air attenuation factor for radon is 0.002. This data indicates that 0.01 is a conservative upper bound subslab-to-indoor-air attenuation factor.

<u>Analysis of Attenuation Factor Implied by Johnson Ettinger Spreadsheet</u>: The USEPA Johnson Ettinger Spreadsheet used to develop the Question 5 screening concentrations in the Vapor Intrusion Guidance uses conservative default values for the input parameters of building volume (244 m^3), building air exchange rate (0.25 hr^{-1}), and soil gas advection rate (0.3 m^3/hr). The building volume and air exchange rate correspond to a building ventilation rate of 60 m^3/hr (i.e., 244 m^3 x 0.25 hr^{-1}). The ratio of soil gas advection rate to building ventilation rate indicates a subslab-to-indoor-air attenuation factor of 0.005 (i.e., 0.3 m^3/hr / 60 m^3/hr). Because Johnson Ettinger Spreadsheet default input parameters are intended to be conservative values based on the distribution of values reported for actual homes, the subslab-to-indoor-air attenuation factor of 0.005 calculated using these input parameter values represents a reasonable upper-bound value for the calculation of subslab screening concentration values.

Although some new energy-efficient homes have air exchange rates as low as 0.1 hr^{-1}, these homes will also have the lowest soil gas advection rates, because a tight foundation is an essential component of the energy-efficient design. Thus, the subslab-to-indoor-air attenuation factor (which is the ratio of these values) should be similar to that used for other homes.

Conclusion: Three different methods to reduce the impact of background indoor air sources on the measured subslab-to-indoor-air attenuation factors in the USEPA Vapor Intrusion Database all support the selection of 0.01 (rather than 0.1) as a conservative upper-bound subslab-to-indoor-air attenuation factor for use in the development of subslab soil gas screening concentrations.

VAPOR INTRUSION ASSOCIATED WITH PETROLEUM HYDROCARBONS

The USEPA Vapor Intrusion Database indicates that subsurface petroleum hydrocarbons do not cause detectable indoor air impacts through vapor intrusion. The indoor air concentrations of petroleum hydrocarbons in the database are consistent with background indoor air concentrations measured at unimpacted sites (i.e., indoor air concentrations reported in the database range from 1 ug/m^3 to 100 ug/m^3, with a median of approximately 10 ug/m^3, a distribution consistent with that reported for unimpacted sites). In addition, the concentrations are not correlated with petroleum hydrocarbon concentrations in groundwater (Figure 3). This evidence of no impact is supported by a similar analysis completed by Groundwater Services, Inc. (GSI) that includes a larger number of data points (59 data points vs. 35 points in the USEPA database) but yields similar results (Figure 3). In addition, Roggemans et al. (2001), have found the biodegradation of petroleum hydrocarbons is generally effective at limiting the migration of petroleum hydrocarbons from groundwater to the ground surface, even below buildings.

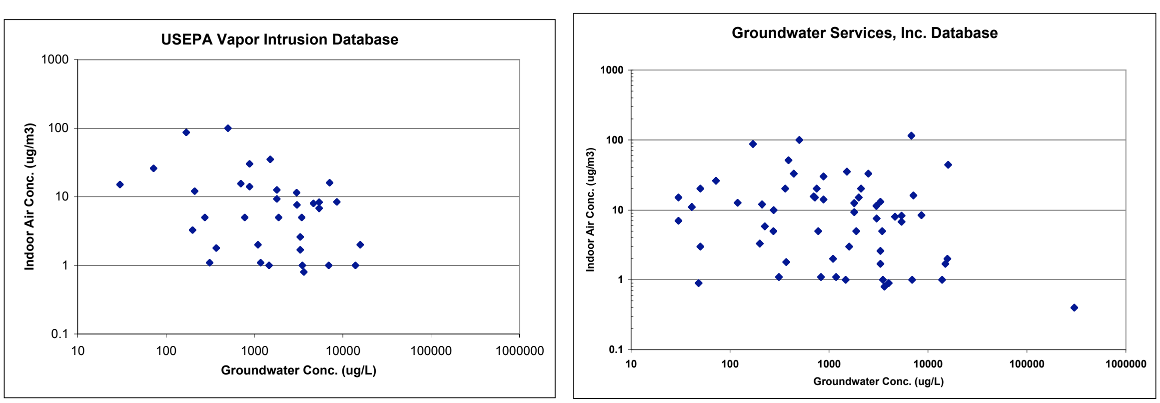

Figure 3. Correlation between Petroleum Hydrocarbon Concentration in Groundwater and Indoor Air: Lack of Correlation Indicates that Groundwater does not Contribute to Measured Indoor Air Concentrations.

Conclusion: The available data indicates that petroleum hydrocarbons in groundwater do not cause detectable indoor air impacts. Based on this evidence, petroleum hydrocarbons should be excluded from the Vapor Intrusion Guidance.

RELIABILITY ASSESSMENT FOR GROUNDWATER SCREENING CONCENTRATIONS

The reliability assessment in the USEPA Vapor Intrusion Guidance presents a misleading evaluation of the utility of the groundwater screening concentrations by indicating a 97% accuracy. The assessment is intended to represent the accuracy with which the groundwater screening concentrations predict indoor air impacts above the indoor air risk-based exposure limit. However, this analysis greatly overstates the correct positive rate and understates the false positive rate associated with application of the groundwater screening concentrations to corrective action sites.

The basic flaw in the reliability assessment is the assumption that 100% of the volatile chemical measured in indoor air is attributable to vapor intrusion. This assumption ignores the available data on background sources presented in the Vapor Intrusion Guidance indicating that average background indoor air concentrations range from approximately 0.1 to 300 ug/m^3 for various common volatile chemicals. The average background indoor air concentration of volatile chemicals such as benzene and trichloroethene is significantly above the indoor air risk-based exposure limit. As a result, the reliability assessment presented in the Vapor Intrusion Guidance can only indicate a correct positive or false negative for these chemicals regardless of whether vapor intrusion is actually contributing to the measured indoor air concentration.

Whenever a conservative upper-bound attenuation factor is used to develop groundwater screening concentrations for evaluation of the groundwater-to-indoor-air pathway, the application of these screening concentrations will inevitably result in false positive indications of vapor intrusion problems at those sites where the upper-bound attenuation factor results in an over-prediction of vapor intrusion. A reliability assessment that cannot accurately characterize this expected false positive rate is not useful for evaluating the utility of the groundwater screening concentrations.

Conclusion: The reliability assessment overstates the correct positive rate for the groundwater screening concentrations by incorrectly attributing background indoor air concentrations to vapor intrusion. This reliability assessment does not present an accurate representation of the utility of the groundwater screening concentrations for identifying vapor intrusion problems and should be eliminated from the Vapor Intrusion Guidance.

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